

PATENT APPLICATION - CERTIFICATE OF EXPRESS MAILING

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Title of Invention: WHEELCHAIR CONTROL SESNSOR USING  
MOVEMENT OF SHOULDERS AND WHEELCHAIR  
DRIVE CONTROL APPARATUS USING THE SAME

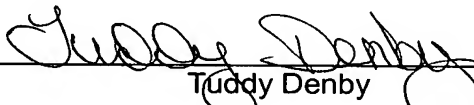
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5        **WHEELCHAIR CONTROL SENSOR USING MOVEMENT OF SHOULDERS AND  
WHEELCHAIR DRIVE CONTROL APPARATUS USING THE SAME**

**Priority Claim**

10        [1]        This application claims priority from Korean Patent Application No. 10-2003-0018856 filed 26 March 2003, which is herein incorporated by reference.

**Field of the Invention**

15        [2]        The present invention relates generally to a wheelchair control sensor for a user who are incapable of moving their hands, and more particularly, to a wheelchair control sensor capable of controlling a powered wheelchair using the movement of the shoulders of spinal cord-injured persons. Additionally, the present invention relates to an apparatus that controls the operation of a wheelchair using the wheelchair control sensor.

20        **Background of the Invention**

25        [3]        Most of spinal cord-injured persons, who are incapable of moving their hands, cannot drive wheelchairs but utilize wheelchairs with the aid of assistants. Furthermore, it is difficult to acquire wheelchairs equipped with control units that can be used by spine cord-injured persons. Currently, there are few wheelchairs that can be used by spine cord-injured persons who are incapable of moving their hands.

[4]        For wheelchairs for handicapped persons, there have been proposed a wheelchair that can be controlled in such a way that a contact type or contactless type switch is mounted on a headrest and the movement of the head of a

5           handicapped person is measured another type of wheelchair has a joystick mounted near the chin of a handicapped person and the joystick is controlled by the chin.

          [5]     For example, U.S. Pat. No. 4,093,037 entitled "Head actuated control unit for battery-powered wheelchair" discloses a technique of controlling a wheelchair through the movement of the head of a handicapped person. A joystick is mounted on a headrest and a handicapped person controls the joystick by moving his or her head. Furthermore, an on/off switch is mounted on the headrest and a wheelchair is turned on/off in case of necessity.

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          [6]     U.S. Pat. No. 4,260,035 entitled "Chin controller system for powered wheelchair" discloses a technique of controlling a wheelchair by controlling a joystick using the chin of a handicapped person. This patent is constructed in such a way that an angle sensor is positioned behind the neck of a handicapped person and the angle sensor is connected to the chin of a handicapped person with a long bar. When a handicapped person moves his or her chin, the angle of the bar that is rotated according to the movement of the chin is measured, and a wheelchair is controlled according to the measured angle. For example, when a handicapped person moves his or her chin in a vertical direction, a wheelchair is controlled to move in forward and backward directions. In contrast, when the handicapped person moves his or her chin in a horizontal direction, the wheelchair is controlled to move in a lateral direction.

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          [7]     Although wheelchairs using the patented techniques have been marketed, most of handicapped persons feel uncomfortable about putting on a special apparatus that is not used by normal persons. Handicapped persons tend not to use wheelchairs equipped with control units that are exposed to the views of other

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5 persons. Further, the prior art technology is inconvenient in that handicapped persons control joysticks by moving their chins, or handicapped persons control joysticks mounted on headrests by moving their heads.

### **Summary Of The Invention**

10 **[8]** It is, therefore, an object of the present invention to provide a wheelchair control sensor, which is worn on the upper body of a spine cord-injured person who is incapable of moving his and her hands, measures the direction and amount of the movement of the shoulders and controls a powered wheelchair, thereby conveniently controlling the powered wheelchair without being concerned about its  
15 appearance.

**[9]** Another object of the present invention is to provide an apparatus for controlling the driving of a powered wheelchair, which is capable of conveniently controlling the powered wheelchair using the wheelchair control sensor.

**[10]** In order to accomplish the above object, the present invention provides a  
20 wheelchair control sensor for controlling a powered wheelchair for a user who is incapable of using their hands, comprising: two casings each including an internal space having an inclined surface; two force sensitive resistor (FSR) sensors attached to the inclined surfaces of the casings or surfaces opposite to the inclined surfaces; pressing balls to press the FRS sensors while being moved through the  
25 internal spaces of the casings by external forces; two shoulder straps for providing the external forces to the pressing balls according to movements of the user's shoulders; and a waist belt worn on an upper body of the user with the two casings spaced apart from each other at a certain interval.

5           **[11]**   In addition, a wheelchair drive control apparatus of the present invention is characterized by receiving a detection signal from a wheelchair control sensor, which controls a powered wheelchair for spinal cord-injured persons using the movement of the shoulders, and controlling operation of wheels of the powered wheelchair.

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### **Brief Description Of The Drawings**

**[12]**   The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

15       **[13]**   FIG. 1 is a schematic diagram illustrating spatial relationships between a wheelchair control sensor configured to detect the movement of the shoulders, a spine cord-injured handicapped person, and a control unit mounted on a powered wheelchair in accordance with the present invention;

20       **[14]**   FIGS. 2a and 2b are an exploded perspective view of the wheelchair control sensor and a view of an assembled wheelchair control sensor, respectively;

**[15]**   FIG. 3 is a see-through view showing the inside structure of the casing of the wheelchair control sensor of FIG. 2b;

**[16]**   FIG. 4 is a sectional view taken along line A-A of FIG. 3, showing the principle of the sensor of FIG. 2b;

25       **[17]**   FIG. 5 is a circuit diagram showing a principle of detecting the resistance value of the wheelchair control sensor of the present invention using a control unit;

5       **[18]** FIG. 6 is a conceptual diagram illustrating the direction of the powered wheelchair that is controlled by the wheelchair control sensor of the present invention;

10       **[19]** FIGS. 7a, 7b and 7c are graphs that compare a functional relationship for converting the movement of the shoulders detected by the wheelchair control sensor of the present invention into the movement of a wheelchair and a conversional relationship for a joystick; and

**[20]** FIG. 8 is a circuit diagram of the wheelchair drive control apparatus using the wheelchair control sensor in accordance with the present invention.

15                               **Detailed Description Of The Preferred Embodiments**

**[21]** Reference now should be made to the drawings, in which the same reference numerals are used throughout the different drawings to designate the same or similar components.

20       **[22]** A wheelchair control sensor using the movement of the shoulders in accordance with a preferred embodiment of the present invention and an apparatus for controlling the driving of a wheelchair using the wheelchair control sensor are described in detail with reference to the appended drawings.

25       **[23]** FIG. 1 is a schematic diagram illustrating spatial relationships between a wheelchair control sensor configured to detect the movement of the shoulders, a spine cord-injured handicapped person, and a control unit mounted on a powered wheelchair in accordance with the present invention.

**[24]** As shown in FIG. 1, a wheelchair control sensor 1 is constructed to be worn on the upper garment of a handicapped person and detect the movement of one or

5 both shoulders of the handicapped person. A control unit 30 is mounted on a  
powered wheelchair 20 to receive detection signals from the wheelchair control  
sensor 10 in a wired manner and control both wheels of the powered wheelchair 20.  
The direction of the powered wheelchair 20 of FIG. 1 is controlled in such a way that  
the control unit 30 receives the detection signals from the wheelchair control sensor  
10 and performs control.

**[25]** FIG. 3 is a see-through view showing the inside structure of the casing of the  
wheelchair control sensor of FIG. 2b. FIG. 4 is a sectional view taken along line A-A  
of FIG. 3, showing the principle of the sensor of FIG. 2b.

15 **[26]** As shown in FIGS. 2a and 2b, the wheelchair control sensor 10 in  
accordance with the present invention includes two casings 11 each having an  
internal space 11b defined by an inclined surface 11a, two force sensitive resistor  
(FSR) sensors 12 attached to the inclined surfaces 11a of the casings 11 or  
surfaces opposite to the inclined surfaces 11a, pressing balls 14 connected to  
20 shoulder straps 13 to press the FSR sensors 12 while being moved upward and  
downward through the internal spaces 11b of the casings 11 by external force, and  
a waist belt 15 worn on an upper garment with the two casings 11 spaced apart from  
each other at a certain interval so that the pressing balls 14 can press the FSR  
sensors 12 while being moved upward and downward by the action of the shoulder  
straps 13.

25 **[27]** Each of the casings 11 has a cubic or hexahedral shape, and is provided  
with the internal space 11b that has a inclined surface 11a having a uniform width  
and a descending inclination. The inclined surface 11a is formed to have the  
descending inclination forward top portion of the internal space 11b. Accordingly,

5       the part of the upper portion of the internal space 11b is narrower than that of the lower portion of the internal space 11b. The internal space 11b is sized so that the pressing ball 14 does not escape from the internal space 11b through the upper end of the internal space 11b after being inserted into therein through the lower end of the internal space 11b.

10       **[28]**   The FSR sensor 12 may be attached to the inclined surface 11a of the casing 11 or a surface opposite to the inclined surface 11a. A connection line connected to an end of the FSR sensor 12 is exposed to the outside of the casing 11 so that signals output from the FSR sensor 12 can be input to the control unit 30. The FSR sensor 12 is a thin film-shaped pressure sensor, and a variable sensor  
15       having characteristics in that, as the external force exerted thereon increases, the resistance value thereof becomes smaller. For example, if it is assumed that force exerted thereon is  $F$ , the resistance value  $R$  can be approximated to be " $aF^b$ ." In this case, " $a$ " and " $b$ " are constants related to the characteristics of the FSR sensor 12 and an area on which the external force is exerted, respectively.

20       **[29]**   The pressing ball 14 is constructed in the form of a sphere having certain size and weight. A through hole 14a is formed through the center line of the pressing ball 14, and a wire 16 is inserted into the through hole 14a. The wire 16 is connected at one end thereof to a stopper 17 having a diameter larger than that of the through hole 14a and at the other end thereof to the shoulder straps 13.  
25       Accordingly, the pressing ball 14 is moved according to the movement of the shoulder straps 13.

**[30]**   Additionally, the waist belt 15 is constructed not only to connect the two casings 11 with a certain interval (generally, narrower than the distance of an adult's



5           shoulders) interposed therebetween, but also to allow the casings 11 to be worn on  
an upper garment. That is, the waist belt 15 not only allows the two casings 11 to be  
spaced apart from each other so as to position the two shoulder straps on the user's  
shoulders, respectively, but also makes the two casings 11 secured to the upper  
garment without displacement even though there is movement in the shoulders.  
10         Accordingly, the waist belt 15 may be constructed in various forms, provided that it  
can secure the casings 11 to the upper garment without displacement.

**[31]**   Each of the shoulder straps 13 is secured to a support portion at a first end  
thereof so that the pressing ball 14 connected to a second end of each shoulder  
strap 13 presses the FSR sensor 12 while being moved along the inclined surface  
15       11a. For example, the second end of each shoulder strap 13 may be provided with  
a clip to allow the second end of each shoulder strap 13 to be secured to the upper  
garment, or may be directly fixed to the waist belt 15, as shown in FIGS. 2a and 2b.  
As described above, the shoulder straps 13 may be secured to any of various  
portions, provided that the pressing balls 14 can press the FSR sensors 12 while  
20       moving along the inclined surfaces 11a of the casings 11 according to the  
movement of the shoulders.

**[32]**   A principle of controlling a powered wheelchair using the wheelchair control  
sensor of the present invention, which is constructed as described above, is  
described below.

25       **[33]**   FIG. 4 is a sectional view taken along line A-A of FIG. 3, showing the  
principle of the sensor of FIG. 2b. FIG. 5 is a circuit diagram showing a principle of  
detecting the resistance value of the wheelchair control sensor of the present  
invention using a control unit.

5           **[34]**   As shown in FIG. 4, when a handicapped person wearing the wheelchair  
control sensor 10 of the present invention raises one or both of his or her shoulders,  
one or both of the shoulder straps 13 located on one or both shoulders raised are  
moved and, therefore, one or both of the pressing balls 14 press one or both of the  
FSR sensors 12 while being moved through the internal spaces 11b of the casings  
10       11. Force equal to reaction force  $F_2$  and force equal to reaction force  $F_3$  are exerted  
on each FSR sensor 12 and the inclined surface 11a, respectively, by the action of  
tension  $F_1$  exerted by the shoulder strap 13. The force exerted on the FSR sensor  
12 through the pressing ball 14 varies according to the extent to which the shoulder  
is raised. Since the FSR sensor 12 is a variable resistor, the resistance value  
15       decreases in proportion to the magnitude of the tension  $F_1$  exerted by the shoulder  
strap 13.

**[35]**   In the wheelchair control sensor 10 of the present invention, the FSR sensors  
12 are positioned in the two casings 11, respectively, and the resistance values of  
the FSR sensors 12 vary according to the magnitude of tensions  $F_1$  exerted on the  
20       FSR sensors 12 (that is, the extent to which the shoulders are raised), thus being  
capable of controlling the direction of the powered wheelchair using the resistance  
values.

**[36]**   The resistance values of the FSR sensors 12 are transmitted to the control  
unit 30 through a voltage divider. As illustrated in FIG. 5, a fixed resistor is  
25       grounded, and  $V_{cc}$  of 5 V is applied to the FSR sensor 12. In this case, when weak  
force is applied to the FSR sensor 12, the resistance value of the FSR sensor 12  
becomes larger and, thus, low voltage is transmitted to the Analog to Digital (AD)  
converter. In contrast, when strong force is applied to the FSR sensor 12, the

5 resistance value of the FSR sensor 12 becomes smaller and, thus, high voltage is transmitted to the control unit 30. The control unit 30 controls the direction of the powered wheelchair according to the transmitted signal.

[37] The direction of the powered wheelchair that is controlled by the wheelchair control sensor of the present invention is described below.

10 [38] FIG. 6 is a conceptual diagram illustrating the direction of the powered wheelchair that is controlled by the wheelchair control sensor of the present invention. As shown in FIG. 6, the wheelchair is operated according to the movement of a handicapped person wearing the wheelchair control sensor 10 of the present invention, as described below. The wheelchair turns to the left when the  
15 handicapped person raises the right shoulder, turns to the right when the handicapped person raises the left shoulder, moves forward when the handicapped person raises both shoulders, and stops or remains stopped when the handicapped person lowers both shoulders. This operational principle is determined based on the phenomenon in which, when a driver rotates the steering wheel of a car, the right  
20 shoulder of the driver is raised at the time of turning to the left, and the left shoulder of the driver is raised at the time of turning to the right.

[39] Furthermore, the wheelchair of the present invention moves backward when both shoulders are quickly raised two times. In accordance with the present invention, turning and forward movement can be performed at the same time. For  
25 example, when the left shoulder is fully raised and the right shoulder is half raised, the wheelchair moves forward while turning to the right.

[40] FIGS. 7a, 7b and 7c are graphs that compare a functional relationship for converting the movement of shoulders detected by the wheelchair control sensor of

5 the present invention into the movement of a wheelchair and a conversional relationship for a joystick. FIG. 7a is a graph showing the functional relationship for converting the movement of shoulders detected by the wheelchair control sensor of the present invention into the movement of a wheelchair, in which the X-axis thereof represents the extent to which a left shoulder is raised and the Y-axis thereof  
10 represents the extent to which a right shoulder is raised. FIG. 7b is a graph representing the movement of shoulders detected by the wheelchair control sensor of the present invention in movement of a powered wheel chair, in which the X-axis thereof represents the velocity of the left wheel of the powered wheelchair and the Y-axis thereof represents the velocity of the right wheel of the powered wheelchair.  
15 FIG. 7c is a graph showing the movement of a wheelchair according to the manipulation of a conventional joystick.

**[41]** As represented by lines □ in FIGS. 7a and 7b, when both shoulders are raised at the same time, the wheelchair moves forward. The higher the shoulders are raised, the faster the wheelchair moves.

20 **[42]** In case of a joystick, as shown in the graph of FIG. 7c, as a joystick is pushed along a Y-axis (that is, line □'), a wheelchair moves forward, and the velocity of the forwarding movement of the wheelchair is determined according to the extent to which the joystick is pushed.

25 **[43]** Lines □ of FIGS. 7a and 7b represents the case where a left shoulder is raised while a right shoulder is kept still. In this case, a powered wheelchair turns to the right. To make a right turn, the left wheel of the wheelchair has to rotate forward and the right wheel has to rotate backward and, therefore, a curve is formed so that an X-axis value increases and a Y-axis value decreases.

**[44]** In case of a joystick, as shown in the graph of FIG. 7c, as a joystick is pulled in the positive direction of an X-axis (that is, line  $\square'$ ), a wheelchair turns to the right, and the velocity of the right turning of the wheelchair is determined according to the extent to which the joystick is pulled.

[45] As described above, the present invention exploits the operational principle of the joystick. The horizontal movement of the joystick controls the angular velocity of the powered wheelchair and the vertical movement of the joystick controls the forward velocity of the powered wheelchair, so that the following Equations 1 and 2 can be set up.

**[46]**  $J_x = \text{Sleft-Sright}$  (1)

$$[47] \quad J_y = S_{left} * S_{right} \quad (2)$$

**[48]** In the above-described Equations 1 and 2,  $J_x$  represents the horizontal coordinates of a joystick,  $J_y$  represents the vertical coordinates of a joystick,  $S_{left}$  represents the extent to which a left shoulder is raised, and  $S_{right}$  represents the extent to which a right shoulder is raised. Each of the parameters is standardized between 0 and 1. Since in the present invention, the movement of the shoulder is standardized between 0 and 1, a signal for moving the powered wheelchair backward cannot be generated. Accordingly, when the powered wheelchair needs to move backward, a method in which a mode is changed by quickly raising both shoulders two times may be used to generate the signal for moving the powered wheelchair backward.

5       **[49]**   The apparatus for controlling the driving of a powered wheelchair using the wheelchair control sensor constructed as described above is described below.

**[50]**   FIG. 8 is a circuit diagram of the wheelchair drive control apparatus using the wheelchair control sensor in accordance with the present invention. As shown in FIG. 8, the wheelchair drive control unit 30 of the present invention is constructed the same as a conventional wheelchair drive control unit except that a powered wheelchair is controlled according to a detection signal input from the wheelchair control sensor 10, instead of a signal input by the manipulation of a joystick. In the wheelchair drive control unit 30 of the present invention, the input signal used to control the powered wheelchair is generated based on the directions in which and the extent to which the FSR sensors 12 are pressed.

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**[51]**   The wheelchair drive control apparatus 30 of the present invention includes a FSR signal input unit 31 for inputting the resistance values of the FSR sensors 12 of the wheelchair control sensor 10 through a voltage divider, a microcontroller 32 for analyzing the FSR signals input from the FSR signal input unit 31 using a defined algorithm and generating an appropriate wheelchair drive control signal, and a wheelchair interface unit 33 for converting the wheelchair drive control signal generated by the microcontroller 32 into a signal suitable for the control specifications of the powered wheelchair. The wheelchair drive control apparatus 30 of the present invention further includes a signal display unit 34 comprised of a light emitting diode (LED) panel for allowing a user to identify signals transmitted to the powered wheelchair, and a control computer interface unit 35 for providing an interface for the use of a control computer to supplement the function of the microcontroller 32. The wheelchair drive control apparatus 30 of the present

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5 invention further includes a wheel drive unit 36 for driving the wheels of the powered wheelchair according to the wheelchair drive control signal, a power supply unit 37 for supplying power, and an emergency stop switch unit 38 for stopping the wheelchair in case of emergency.

10 [52] The wheelchair drive control apparatus 30 of the present invention constructed as described above controls the powered wheelchair using a signal input from the wheelchair control sensor 10 and the above-described component elements in the same manner as the conventional wheelchair drive control apparatus.

15 [53] As described above, in accordance with the present invention, a wheelchair control sensor is worn on the upper garment of a spine cord-injured person who is incapable of moving his and her hands, measures the direction and amount of the movement of shoulders and controls a powered wheelchair, so that the injured person conveniently controls the powered wheelchair without being concerned about its appearance.

20 [54] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.